Simulation of Multipacting in ILC 1.3 GHz Cavity HOM Coupler

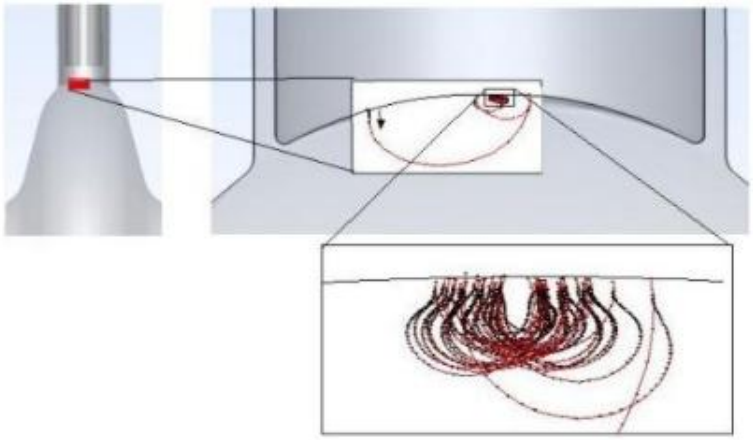
Sergey Antipov

Supervisors: Vyacheslav Yakovlev,

Ivan Gonin

Multipacting

- A phenomenon of resonant electron multiplication in which a large number of electrons build up an electron avalanche.
- 2 conditions:
  - An electron returns back to the same point of the surface after an integer number of RF cycles. (Resonant condition)
  - The impacting electron produces more than one secondary electron.



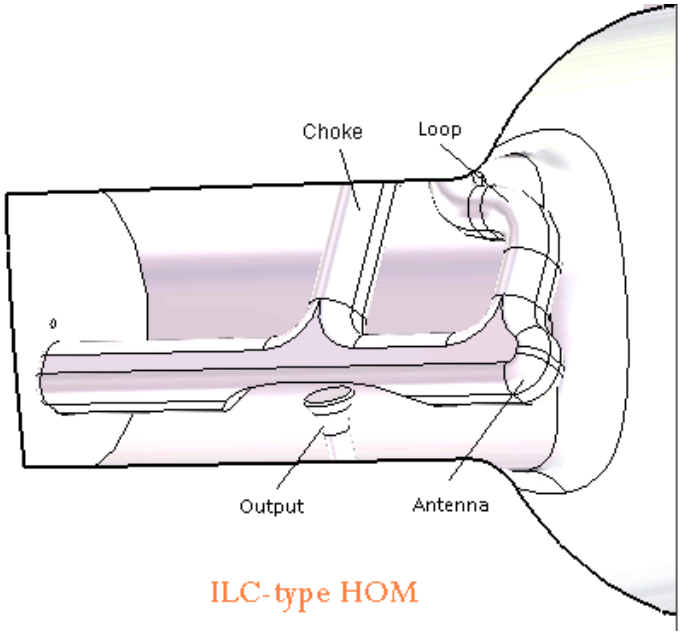
Motivation

- Resent measurements show that the temperature of ILC 1.3 GHz HOM rises when RF field is applied in wide range of accelerating gradients from 5 to 34 MeV/m.
- This most probably means that a multipacting occurs.
- According to previous works the multipacting should not exist if the coupler is treated properly.

- The goal of this work is to study if there are resonant conditions for multipacting in HOM coupler and to explore how the coupler material treatment influences the multipacting.

HOM coupler

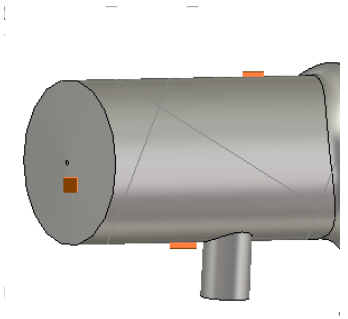
- HOM damper is an expensive and complex part of SC acceleration structure.
- It's complicated geometry makes it hard to clean its surface properly. Contaminations like oxides, sulfur etc might exist.
- This may lead to multipactorir

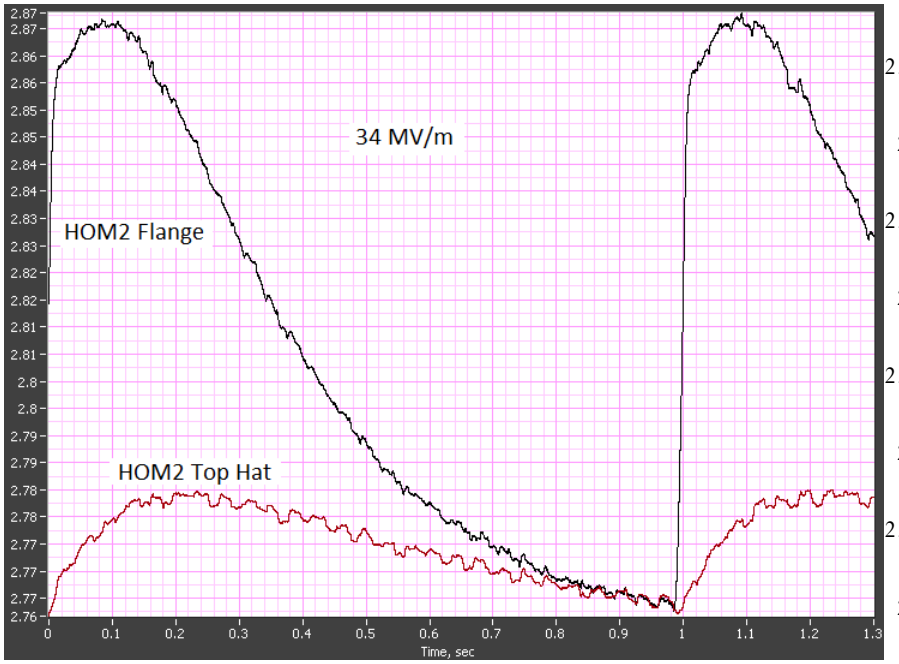


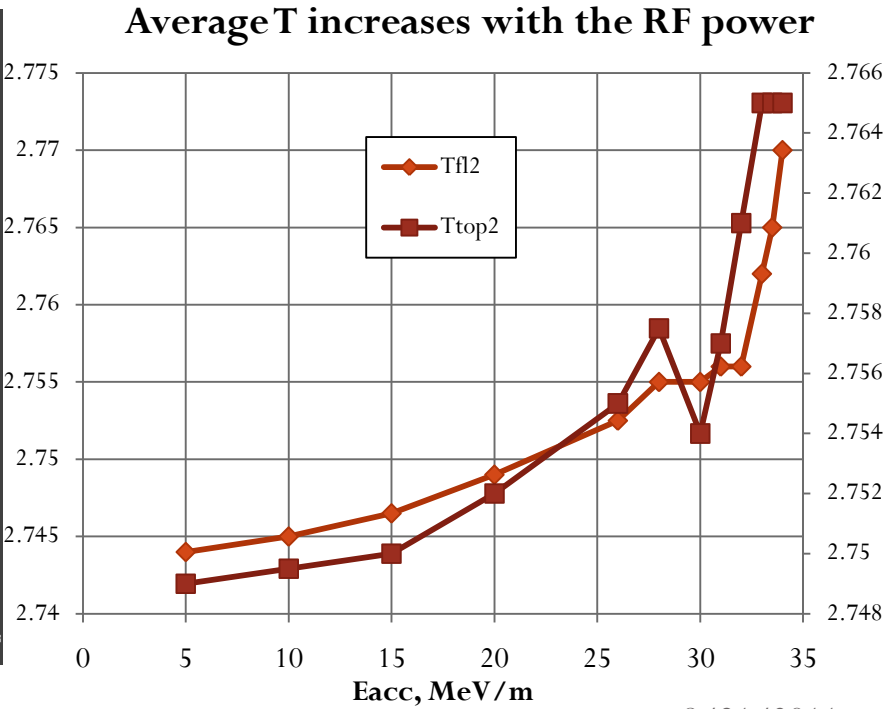
ILC-type HOM

Temperature tests

- 3 sensors were installed to measure T (orange)
- Pulsed RF were applied with pulse length 1ms and freq 1Hz.
- Maximum temperature rise was detected near the flange

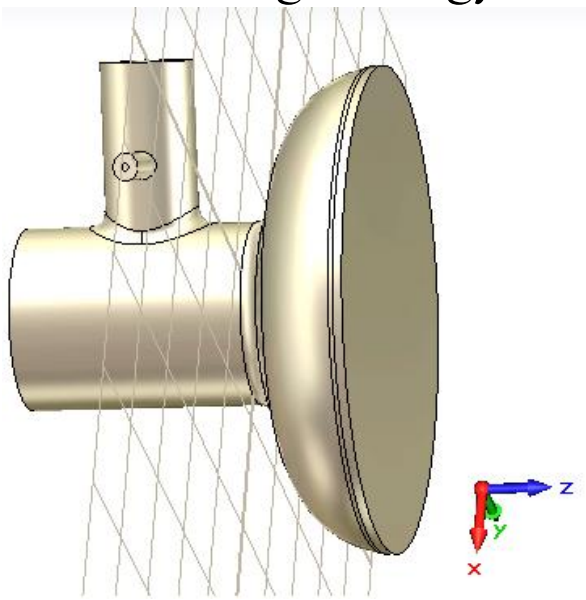






Simulation. Step 1

- The analysis was made in 2 steps. First step:
  - Eigenmode problem was solved to find field distribution within the HOM damper.
  - The structure of a coupler with ½ of the end cell was studied (pic.)
  - Only main mode was considered because of its large energy.

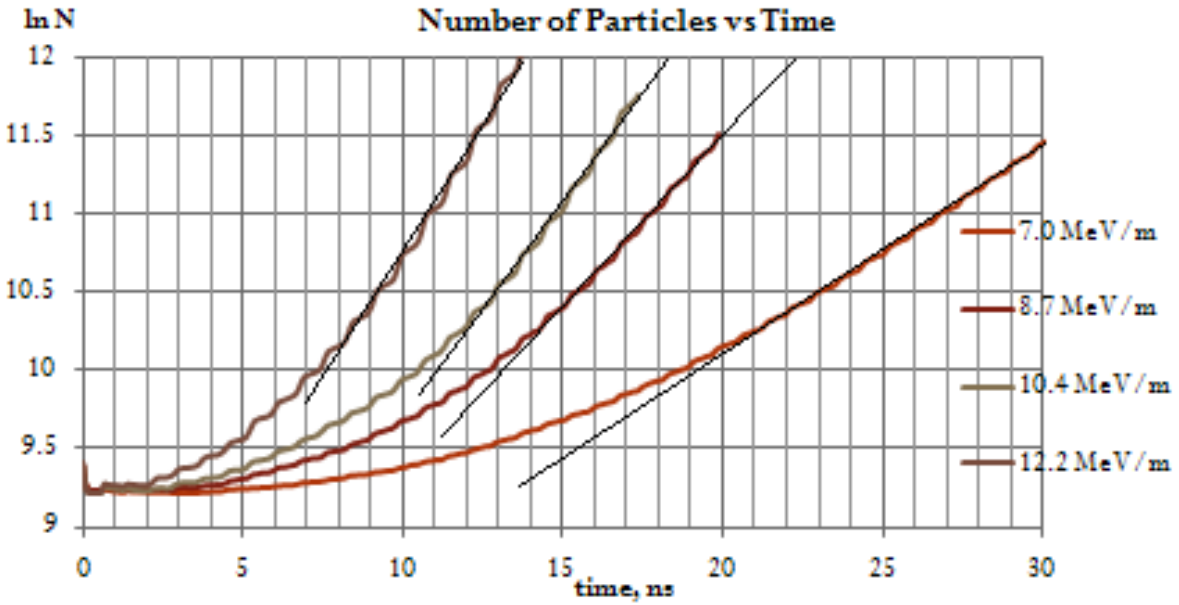


Software: CST Microwave Studio

Simulation. Step 2

- Particle tracking simulations were performed using the field pattern from the previous step.
- A big number of initial particles (more than 10^4) was placed on the faces of HOM.
- If multipacting: $N \sim \exp(\alpha \cdot t)$

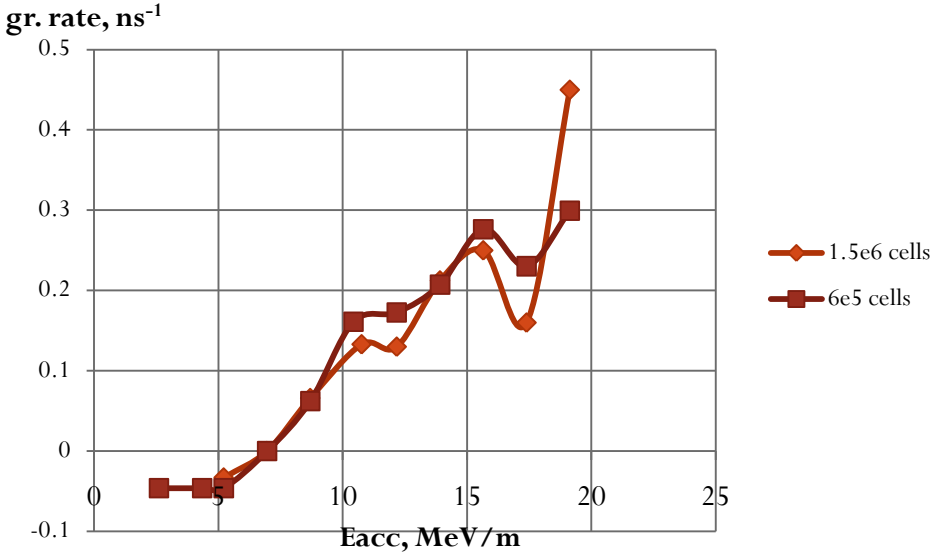
Growth Rate



Software:
SCT Particle Studio

Convergence

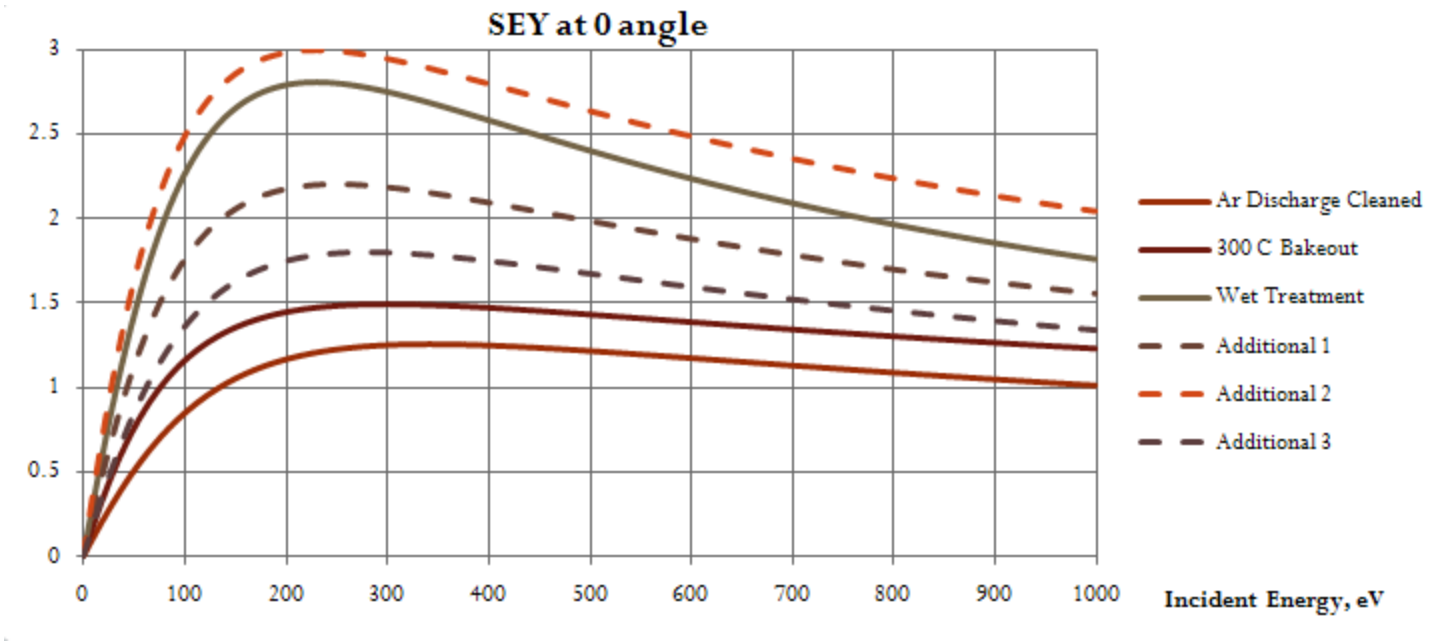
- Particle tracking convergence was tested on different meshes with numbers of cells differed up to 8.3 times.
- Though some discrepancy in results exits the qualitative picture remains the same.



8 MeV/m, Wet Treatment	Growth Rate
$0.6 * 10^6$ cells	0.08 ns^{-1}
$1.5 * 10^6$ cells	0.065 ns^{-1}
$3.0 * 10^6$ cells	0.06 ns^{-1}
$5.0 * 10^6$ cells	0.075 ns^{-1}

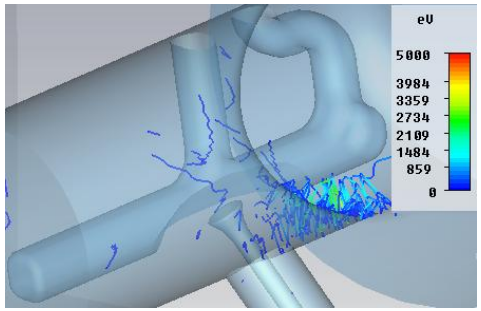
Simulation. Material Properties

- HOM surface has homogeneous emission properties.
- 3 standard SEY curves for different treated Nb were taken from SCT Studio material library and 3 more curves were added.

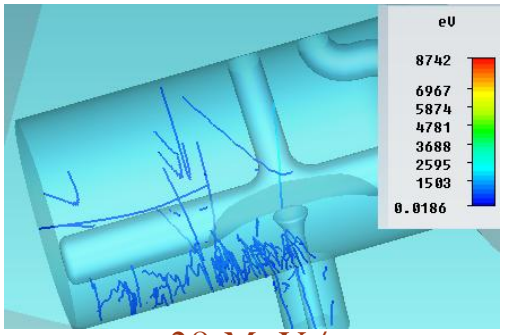


Results. Places of multipacting

- There is a place of 1-wall multipactor near the flange.
- Energy range: 5 – 35 MeV/m
- With energy increase multipactor moves to the top. At about 20 MeV/m it crosses the place of the output.

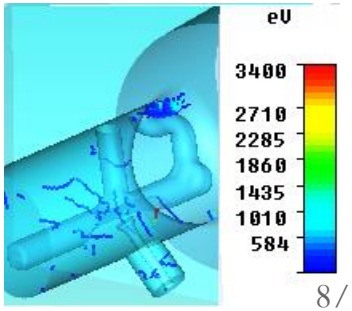


10 MeV/m

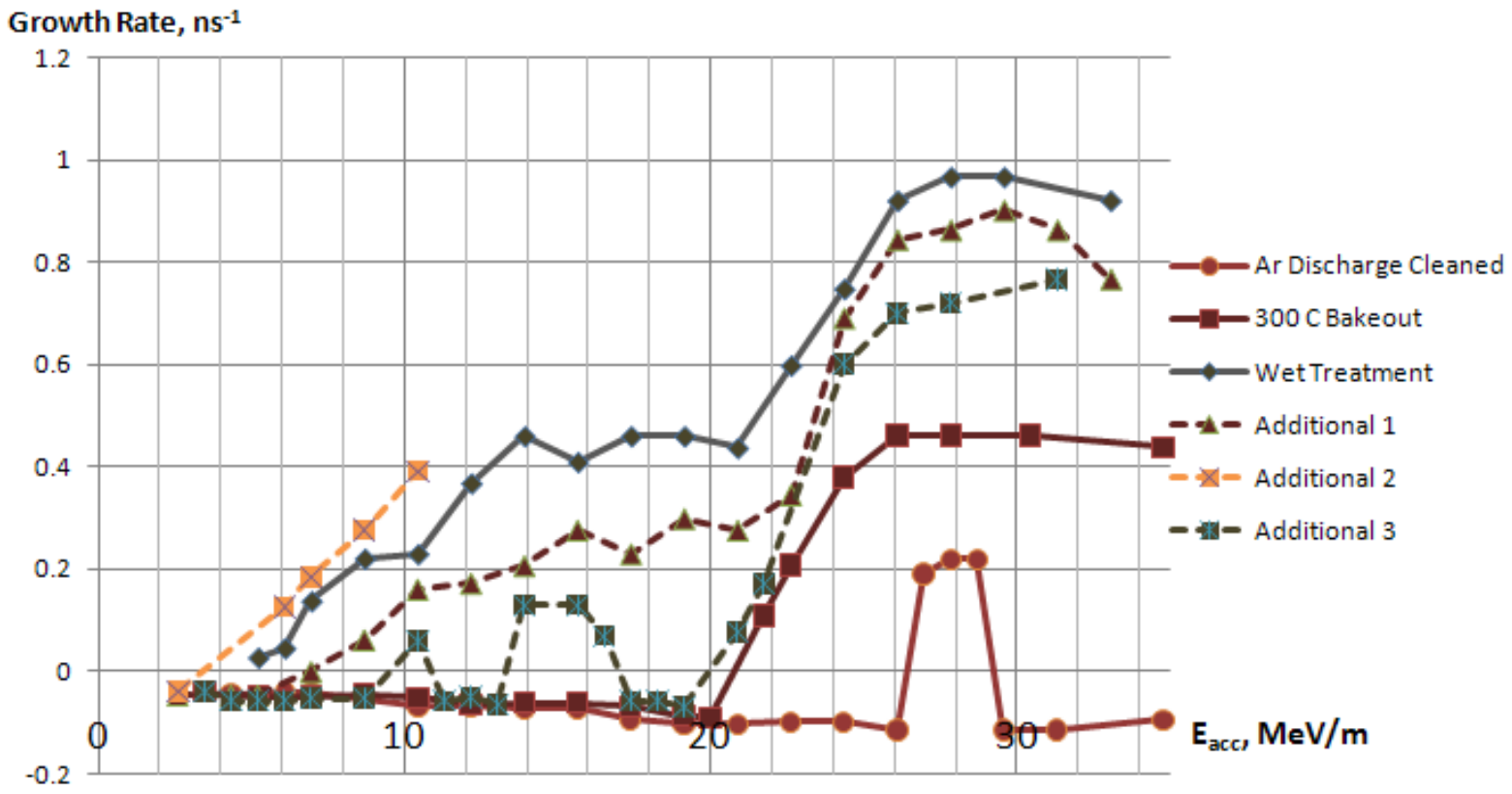


28 MeV/m

- Also simulations found a place of 2-wall multipacting on the loop. The resonant conditions here are met under gradients higher than 20 MeV/m.



Results for different SEY



Conclusions

- If the HOM is treated properly the multipacting should not take place except relatively small energy region.
- However if the Nb is not sufficiently clean a multipacting in a wide range of accelerating gradients may exist in the HOM.
- In that case particle growth rate increases with the RF power which is consistent to what was measured in the temperature tests.
- Some discrepancy between the results of tests and simulations can be attributed to inhomogeneity of the real surface.

Thank you

Any Questions?